

REMARKS

Applicants wish to thank Examiner Bullock for indicating allowability of Claims 11 and 12.

Applicants respectfully request reconsideration of the application, as amended, in view of the following remarks.

The rejection of Claims 1-10, 13, and 14 under 35 U.S.C. § 103(a) over Culp et al in view of WO 98/29365 is respectfully traversed.

The present invention as set forth in **Claim 1** relates to a process for the continuous heterogeneously catalyzed partial dehydrogenation of at least one hydrocarbon to be dehydrogenated in the gas phase, in which

- a reaction gas comprising at least one hydrocarbon to be dehydrogenated is fed continuously to a reaction zone,
- the reaction gas in the reaction zone is conveyed over at least one fixed catalyst bed over which molecular hydrogen and at least one dehydrogenated hydrocarbon are formed by catalytic (partial) dehydrogenation,
- at least one gas comprising molecular oxygen is added to the reaction gas before and/or after entry into the reaction zone,
- the molecular oxygen in the reaction zone oxidizes part of the molecular hydrogen present in the reaction gas to water vapor, and
- a product gas comprising molecular hydrogen, water vapor, the dehydrogenated hydrocarbon or hydrocarbons and the hydrocarbon or hydrocarbons to be dehydrogenated is taken from the reaction zone,

wherein the product gas taken from the reaction zone is divided into two substreams of identical composition and one of the two substreams is recirculated as circulated gas to the reaction zone.

The present invention is directed to a heterogeneously catalyzed partial dehydrogenation of hydrocarbon. Some features of such reaction are as follows:

The specification describes at page 2, line 42 that the conversion which can be achieved is limited by the thermodynamic equilibrium. At least one molecule of hydrogen is produced per molecule of dehydrogenated hydrocarbon (page 2, line 45 of the specification). The dehydrogenation is endothermic (page 3, line 3 of the specification). The added molecular oxygen burns the molecular hydrogen formed during dehydrogenation (page 3, line 39 of the specification). **The present invention differs from catalytic oxydehydrogenation in which hydrogen is split off directly as water** (page 4, line 44 of the specification).

In contrast, Culp's "oxidative dehydrogenation" is nothing but a "oxydehydrogenation" having the following characteristic features:

The conversion is not thermodynamically limited (column 1, line 39 of Culp et al). The reaction is highly exothermic (column 1, line 56 of Culp et al). One molecule of water is produced per molecule of dehydrogenated hydrocarbon (column 8, all reaction equations of Culp et al). Hydrogen is not formed as consequence of dehydrogenation, but only in minor amounts via the water-gas shift reaction between water and carbon monoxide formed as by-product (column 9, line 12 of Culp et al). Hydrogen formed does not react with oxygen, but the lower alkane itself reacts directly with oxygen (column 10, line 9 of Culp et al).

In other words, Culp's process is exactly what the present invention wants to avoid (see page 4, line 44 of the specification). Due to this nothing can be derived from Culp for the claimed process.

Additionally, Culp does not recycle reaction product itself into dehydrogenation, but only the remainder after splitting of the olefin formed. This is completely different from the present invention. Furthermore it could not be expected from Culp that the recycling of the present invention, despite of having the highly reactive olefin in the cycle stream, results in

reduced carbon oxide formation as shown from the results in Table 2 and Table 3. Table 2 pertains to Comparative Example 2 and Table 3 pertains to the Example according to the present invention.

The following is reproduced from pages 22 -24 of the specification as originally filed.

“Table 2 below reports the results achieved as a function of the time of operation (time from the change to the new reaction conditions). The % by volume figures are once again based on ”dry” gas.

Table 2

	Reaction gas % by volume	Product gas (after 3 h) % by volume	Product gas (after 20 h) % by volume
Propane	73.16	45.43	46.49
Propene	0.007	14.40	14.03
H ₂	0	17.56	17.01
O ₂	5.34	0	0
N ₂	21.50	19.28	18.97
Methane	0	0.16	0.24
Ethane	0.0012	0.20	0.22
Ethene	0	0.05	0.07
CO	0	0.16	0.16
CO ₂	0	2.77	2.81

Comparison with Table 1 shows that the presence of atmospheric oxygen results both in an increase in CO_x formation and in increased formation of cracking products (methane, ethane and ethene). Both reduce the selectivity of propene formation. The latter was, based on a single pass of the reaction gas and a propane conversion of 24.6 mol%, determined as 91.4 mol%.”

“Table 3 below reports the results achieved as a function of the time of operation (time from change to the new reaction conditions). The volume % figures are once again based on “dry” gas.

Table 3

	Inlet gas % by volume	Product gas (after 3 h) % by volume	Product gas (after 20 h) % by volume
Propane	73.08	60.15	57.97
Propene	0.007	13.10	14.51
H ₂	0	5.36	6.94
O ₂	5.36	0	0
N ₂	21.55	20.73	19.93
Methane	0	0.04	0.04
Ethane	0.0009	0.12	0.13
Ethene	0	0.12	0.11
CO	0	0.01	0.02
CO ₂	0	0.37	0.36

Comparison of Table 3 with Table 2 shows that operation with recirculation of gas according to the present invention suppresses the increase in CO_x formation in Comparative Example 2 caused by addition of air and the formation of cracking products (methane, ethane and ethene) to a level, based on propene formed, which corresponds almost to that in Comparative Example 1 which was carried out with exclusion of oxygen. This displays an increase in selectivity of propene formation compared to Comparative Example 2. Furthermore, the numerical values for the hydrogen content compared to Table 2 show that the recirculated hydrogen has largely been oxidized selectively by the atmospheric oxygen. Based on a single pass of the inlet gas, the selectivity of propene formation was 98.0 mol% at a propane conversion of 20.3 mol%.”

WO 98/29365 does not cure the defects of Culp et al.

Therefore, the rejection of Claims 1-10, 13, and 14 under 35 U.S.C. § 103(a) over Culp et al in view of WO 98/29365 is believed to be unsustainable as the present invention is neither anticipated nor obvious and withdrawal of this rejection is respectfully requested.

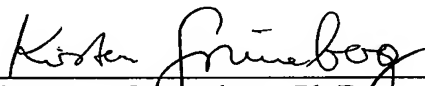
The rejection of Claim 12 under 35 U.S.C. § 112, 2nd paragraph, is obviated by the amendment of Claim 12.

This application presents allowable subject matter, and the Examiner is kindly requested to pass it to issue. Should the Examiner have any questions regarding the claims or otherwise wish to discuss this case, he is kindly invited to contact Applicants' below-signed representative, who would be happy to provide any assistance deemed necessary in speeding this application to allowance.

Respectfully submitted,

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